

REMARKS

Reconsideration and allowance of this application, as amended, is respectfully requested.

This amendment is in response to the Office Action dated November 6, 2003.

By the present amendment, the Title has been amended as required in paragraph 5 of the Office Action. Also, the claims have been amended, where appropriate, for clarification, as will be discussed below. In addition, Fig. 10 of the drawings has been amended to correct an informality noted in review of the case, as will also be discussed below.

Briefly, the present invention is directed to providing an improved semiconductor device having a semiconductor chip with a rectification function in a case electrode. As discussed in the Background of the Invention, such semiconductor devices are frequently used for rectifying the output of an AC generator into a DC output signal. This is typically required, for example, in automobile electrical systems. However, as also discussed in the Background of the Invention, the operating environment for such semiconductor devices in an automobile is an extremely harsh one, and the device is frequently subjected to thermal shocks during normal operation.

For purposes of developing an improved device, the Applicants performed studies on a device such as shown in Fig. 10 and discussed on page 15. From their studies, Applicants determined that a device such as shown in Fig. 10 is subject to undesirable cracking in the chip. This is discussed, for example, on page 15, line 25 et seq. As noted there, this problem stems from the fact that the width of the electrically conductive plate 4 is equal to the maximum width of the semiconductor

chip 2 (noting that the amendment to the drawing corrects the numeral error in the numbering of elements 2 and 4, as will be discussed below with regard to the drawings). In addition, as discussed on page 16, line 5 et seq., since the electrically conductive plate 4 is located between the chip 2 and the heat radiating case electrode 5, heat is not effectively radiated from the chip to the heat radiating case electrode 5.

Accordingly, the embodiments of the present invention were developed to overcome the above-noted difficulties from the diode studied by the inventors in Fig. 10. Regarding this, reference will be made to the elected Fig. 4 in the following discussion to explain the advantage of the invention (noting, however, that reference to Fig. 4 is solely for purposes of example, and not intended to limit the invention only to the specifics of Fig. 4).

To begin with, as noted in Fig. 4, the electrically conductive plate 4 is located between the semiconductor chip 2 and the lead electrode 1, rather than being located between the semiconductor chip 2 and the case electrode 5. This serves to significantly improve the heat conduction between the chip and the case electrode 5, as discussed on page 4, line 1 et seq. and page 18, line 21 et seq. In addition, the maximum width of the electrically conductive plate 4 is set to be less than the maximum width of the semiconductor chip 2. This is shown, for example, in more specific detail in Fig. 8, but applies to the embodiment of Fig. 4 as well. This difference in widths, together with the location of the electrically conductive plate 4 between the semiconductor chip and the lead electrode serves to provide an overall structure which reduces cracks to the semiconductor chip 2.

In accordance with another aspect of the present invention, the coefficient of linear expansion of the electrically conductive plate 4 is set to be smaller than that of the case electrode, as discussed, for example, on page 5, line 12 et seq. A further aspect of this is that the coefficient of linear expansion of the electrically conductive plate can also be said to be equal to or larger than 50% of that of the semiconductor chip (page 5, lines 16 and 17). As discussed on page 6, this feature serves to reduce the stress generated in the semiconductor chip.

With regard to the above discussion, it is noted that a comparison has been made between the embodiments of the present invention, such as Fig. 4, and the arrangement shown in Fig. 10 which has been defined in the specification as a "structure of a diode for comparison." In reviewing Fig. 10, it was realized that the numerals 2 and 4 had been switched. Therefore, the present amendment corrects this numbering error. It is noted that the correction shows the semiconductor chip 2 being connected to the lead electrode 1 through the connection member 3a, as per page 15, lines 5-7. The electrically conductive plate 4, on the other hand, is now shown in the corrected Fig. 10 as being connected to the case electrode 5 through the connection member 3c, as described on page 15, lines 12-15. Thus, the correction to Fig. 10 serves to correctly correlate the numbering of Fig. 10 with the description of Fig. 10 provided on page 15, lines 5-15. Thus, this correction is not new matter, and entry of this correction for clarification of the drawing is respectfully requested.

Reconsideration and removal of the objection to Fig. 10 of the drawing is respectfully requested. In the Office Action, it is stated that Fig. 10 should be labeled as prior art. However, as noted above, the specification describes Fig. 10 as being a

"structure of a diode for comparison" as set forth on page 14, line 22. Page 14, line 27 et seq. describes Fig. 10 as "the basic structure of a diode for comparison." In other words, there is no statement in the specification that Fig. 10 is actually prior art. On the contrary, Fig. 10 is actually a device which was developed by the inventors to study to arrive at the invention shown in the other figures. Therefore, it is respectfully submitted that Fig. 10 is not prior art in the accepted meaning of that term within patent law, and reconsideration and removal of the requirement for labeling it as such is respectfully requested.

With regard to the objections to the drawings set forth in paragraph 10, claim 10 has been amended to clarify the matter addressed in the Office Action. Therefore, it is respectfully submitted that no further amendment to the drawing is necessary. Therefore, removal of this basis of objection is also respectfully requested.

Reconsideration and removal of the 35 U.S.C. § 112, second paragraph, rejection of claims 5 and 10 is also respectfully requested. By the present amendment, both claims 5 and 10 have been amended to address the issues set forth in the Office Action. As such, it is respectfully submitted that the amended claims 5 and 10 clearly meet the requirements of 35 U.S.C. § 112, second paragraph, and removal of the rejections regarding this is earnestly solicited.

Reconsideration and allowance of amended claims 1 and 9 over U.S. Patent 5,206,793 to Boudrant is respectfully requested. By the present amendment, each of claims 1 and 9 has been amended to specifically define that the connection members are soldering connection members. This corresponds, for example, to the disclosure found on page 15, lines 15 and 16 that "each of those connection

members 3a, 3b and 3c is generally made of solder.” As such, this is completely contrary to the arrangement taught by Boudrant on column 2, lines 54-56 which states:

“The two electrodes 4 and 5 are kept assembled on the opposite sides of the chip 2, by simple intimate contact of electrical and thermal conduction under the permanent action of a pressure exerted by an elastic element.”

Thus, Boudrant does not teach or suggest solder, and, on the contrary, teaches specifically away of the use of such solder. As such, Boudrant will not obtain the beneficial effects of the present invention of providing an overall structure, including solder connections, which will not suffer from cracking due to thermal deformation differences between the case electrode and the semiconductor chip. Therefore, reconsideration and allowance of amended claims 1 and 9 over Boudrant is respectfully requested.

Reconsideration and allowance of claims 1-3 over U.S. Patent 3,315,136 to Lob is also respectfully requested. By the present amendment, claims 1 and 9 have both been amended to define that a maximum width of the electrically conductive plate is smaller than a maximum width of the semiconductor chip. This is clearly neither taught nor suggested in Lob. More specifically, in Lob, the copper plate 11, which the Office Action has equated to the claimed electrically conductive plate, is clearly much larger than the semiconductor element 8 shown in Lob. Thus, Lob will not achieve the advantage of reduced cracking of a semiconductor chip by virtue of the setting of the maximum size of the electrically conductive plate to be smaller than the maximum size of the semiconductor chip, as defined by amended claim 1.

Therefore, reconsideration and allowance of amended claim 1 over Lob is also respectfully requested.

Reconsideration and allowance of claims 1, 9, 10 and 11 over U.S. Patent 4,305,088 to Narita is also respectfully requested. By the present amendment, amended claims 1, 9, 10 and 11 all define that the coefficient of linear expansion of the electrically conductive plate is smaller than that of the case electrode. This limitation is completely lacking from Narita, as apparently recognized in the Office Action by virtue of the fact that claim 2, containing this limitation, is not rejected over Narita. Therefore, reconsideration and allowance of these amended claims 1, 9, 10 and 11 over Narita is also respectfully requested.

Finally, reconsideration and allowance of claim 5 over the combination of Boudrant and Yokoyama (GPO 07-221235) is also respectfully requested. As noted above, the Boudrant reference fails to teach or suggest the specific feature of soldering connections defined in the amended claim 1. Nothing in Yokoyama suggests any modification of Boudrant which would lead to overcoming this shortcoming. Therefore, reconsideration and allowance of claim 5 over this combination of references is also respectfully requested.

If the Examiner believes that there are any other points which may be clarified or otherwise disposed of either by telephone discussion or by personal interview, the Examiner is invited to contact Applicants' undersigned attorney at the number indicated below.

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to the Antonelli, Terry, Stout & Kraus,


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LLP Deposit Account No. 01-2135 (Docket No. 500.41144X00), and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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